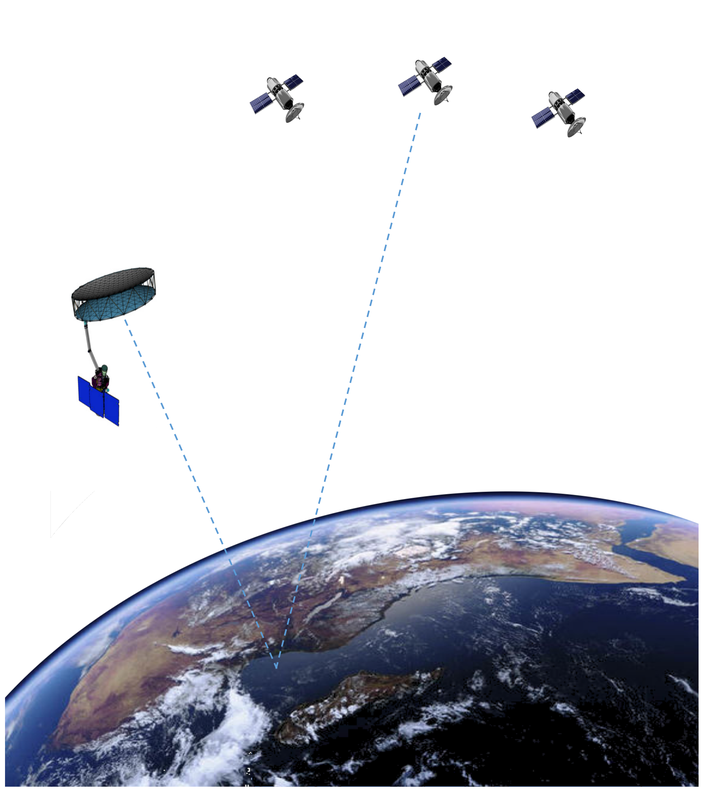
Sensitivity Analysis of SMAP-Reflectometry (SMAP-R) Signals to Vegetation Water Content

Nereida Rodriguez-Alvarez, Sidharth Misra and Mary Morris
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, US



SMAP radar receiver bandpass center frequency was switched to 1227.45 MHz enabling GNSS-R capabilities:

Specifics
- Measuring GPS L2C from Aug. 20, 2015.
- Sun-Synchronous orbit altitude: 685 km, inclination: 98.12º.
- Near-global revisit coverage in 2–3 days
- SMAP-R Goal: To investigate the benefits of having measurements at dual polarization and high gain.

Limitations
- Calibration: Lack of direct signal information and effect of the narrow beam antenna.
- Reduced sampling: Rotating narrow antenna beam antenna.

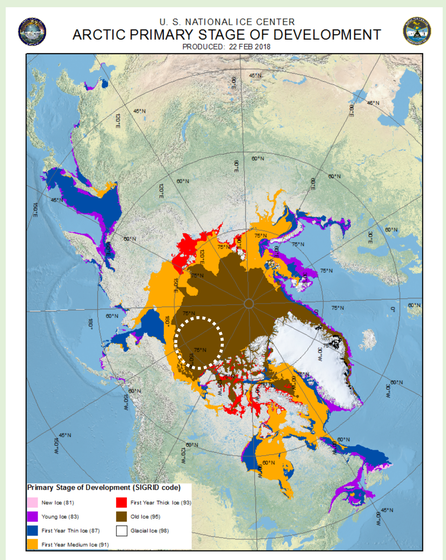
Benefits
- High gain antenna: Lower integration times produce same CYGNSS dynamic range.
- Dual-polarization: Polarimetric studies
- Fixed geometry [37.5º - 42.5º]: Less variability on the GPS transmitter parameters.
- Availability of raw data: Versatility on processing data at shorter integration times optimizing the spatial resolution and benefiting science applications.

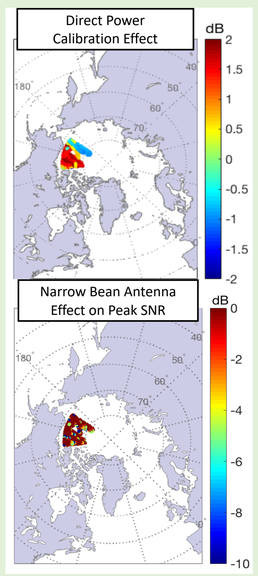
Calibration

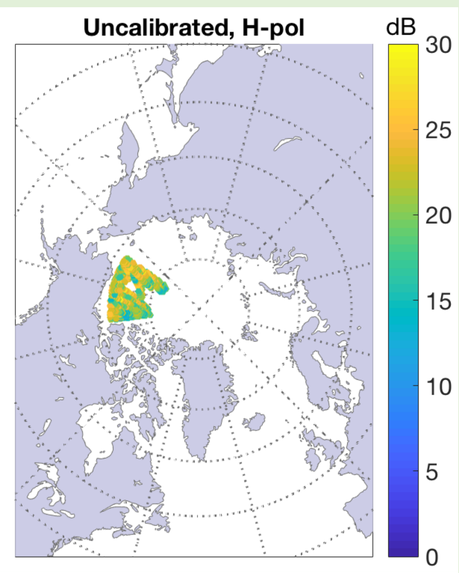
- Lack of direct signal information
- Narrow beam antenna effect

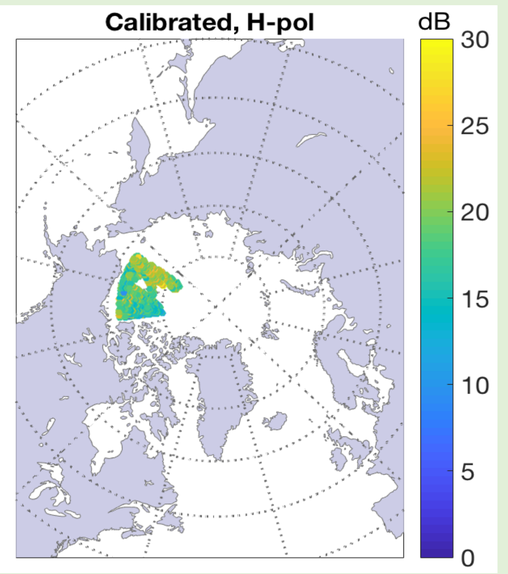
$$\langle \sigma_0 \rangle = \frac{(4\pi)^3 P_{incoh}(\tau, f_d)\, R_{rx_{sp}}^2 R_{tx_{sp}}^2}{T_i^2 P_{tx} G_{tx} \lambda^2 G_{rx_{sp}} \bar{B}(\tau, f_d)}$$

QUALITY CHECK:
Calibration is tested over an area of constant old sea ice, whose scattering properties remain constant over an extensive area and over the days for February 2018.



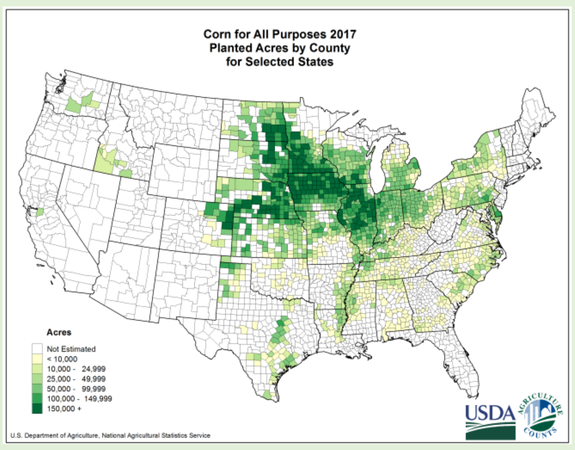




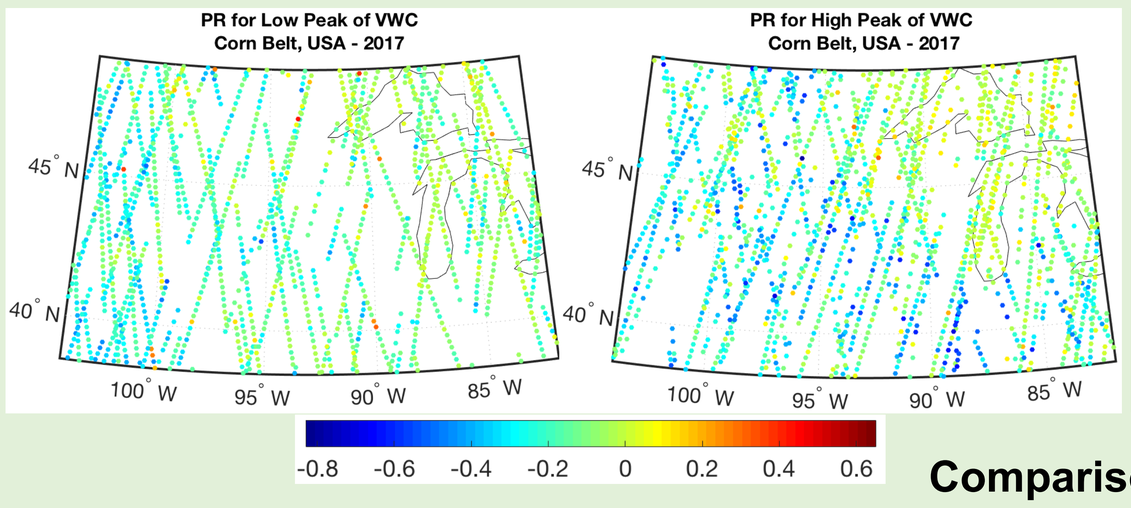


Vegetation Water Content Analysis

The Study Area: U.S. Corn Belt

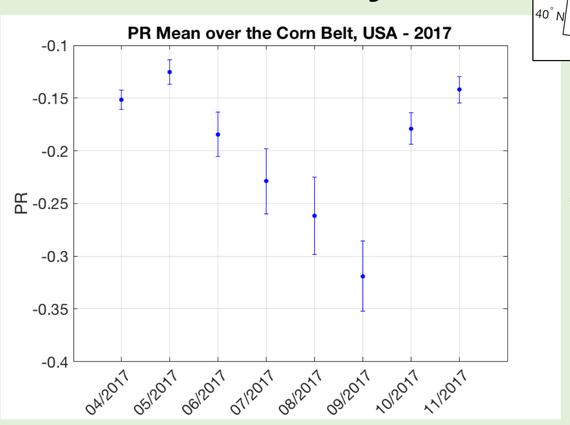


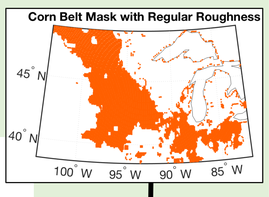
The Measurements: The Polarimetric Ratio (PR)



As the VWC increases, PR decreases.

Seasonal Variability

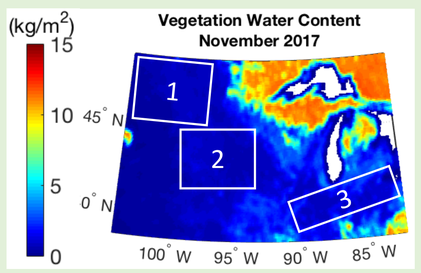


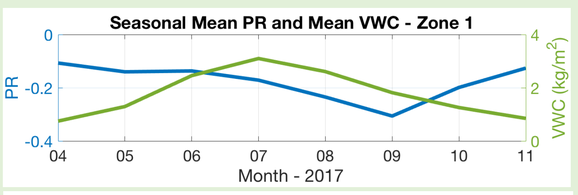


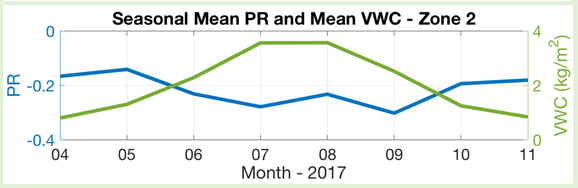
Corn Belt Area Roughness Mask set to low roughness in the range [0.1 – 0.112]

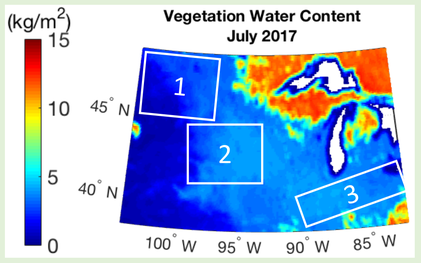
Values correspond to unitless values that are indicative of bare soil roughness within SMAP 9 km grid cell (0 min, 1 max)

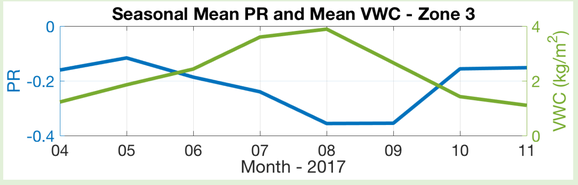
Comparison to SMAP Ancillary Dataset











VWC and PR are inversely proportional ➔ The PR keeps decreasing even when VWC decreases (plants dry), hence the vegetation height still affects. After harvest (October) PR increases systematically to original levels.

Conclusions

- Calibration of SMAP-R signals is challenging due to the SMAP-R observational characteristics.
  - Calibration is a key step to producing science from the SMAP-R dataset.
- SMAP-R low sampling limits applications needing high temporal repeat.
  - Different strategies can be implemented based on a 2-state transition observational strategy.
- The polarimetric sensitivity and high antenna gain of SMAP-R represent great assets to assess VWC and understand agricultural productivity
  - H-pol and V-pol measurements brings extra capabilities to reduce the error on the VWC estimations.
- Results prove the sensitivity of L-band polarimetric measurements to VWC and the benefit of SMAP-R spatial resolutions.
- SMAP-R is sensitive to VWC transitions.
- We are working on implementing an algorithm to ingest SMAP-R measurements and obtain VWC of the observed surfaces. We need to account for soil moisture, roughness and vegetation height.

SEE ALSO

CHARACTERIZATION OF THE LAND/SURFACE F/T STATE WITH SMAP-R
FR4.R2: Freeze-Thaw Status and Lake Ice, August 2, 2019
SPACEBORNE GNSS-R USING THE SMAP RADAR RECEIVER (SMAP-R): OCEAN WIND VECTOR SENSITIVITY INVESTIGATION
WE3.R12: Ocean Surface Winds and Currents V

Acknowledgements

Thanks to Stephen Lowe and Stephan Esterhuizen for the earlier efforts and developments of the DDM processor at the Jet Propulsion Laboratory.

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. The research is supported by the JPL fund on R&A Hydrology & Weather from the Soil Moisture Active Passive (SMAP) project. © 2019. California Institute of Technology. Government sponsorship acknowledged.